Technology for Cleaning the External Surfaces of Air-Cooled Condensers

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Air Cooled Condensers

Air cooling may be the only practical condensing technology for certain sites

- Mine-mouth power plant with inadequate local cooling water source (Black Hills, WY)
- Plant situated in a desert (El Dorado, NV)
- Cooling tower plume and fog would endanger highway safety (Wyodak, WY)
- Thermal pollution with once-through system must be avoided (Athens, NY)
- Conventional cooling towers intrude on rural landscape or degrade a residential area, making a permit difficult to obtain

Air Cooled Condensers

- Installed cost tends to be more expensive than their water-cooled equivalents
- An energy penalty can be incurred during summer conditions
- EPA does not consider air cooling to be the Best Available Technology (BAT)

Features of Air Cooled Condensers

- A-Frame Construction
- Finned tubes
- Parallel Flow Condensing Sections
- Counter Flow Condensing Sections
- Fans located in Base of A-frame
- Lengthy and large diameter exhaust piping prone to air inleakage

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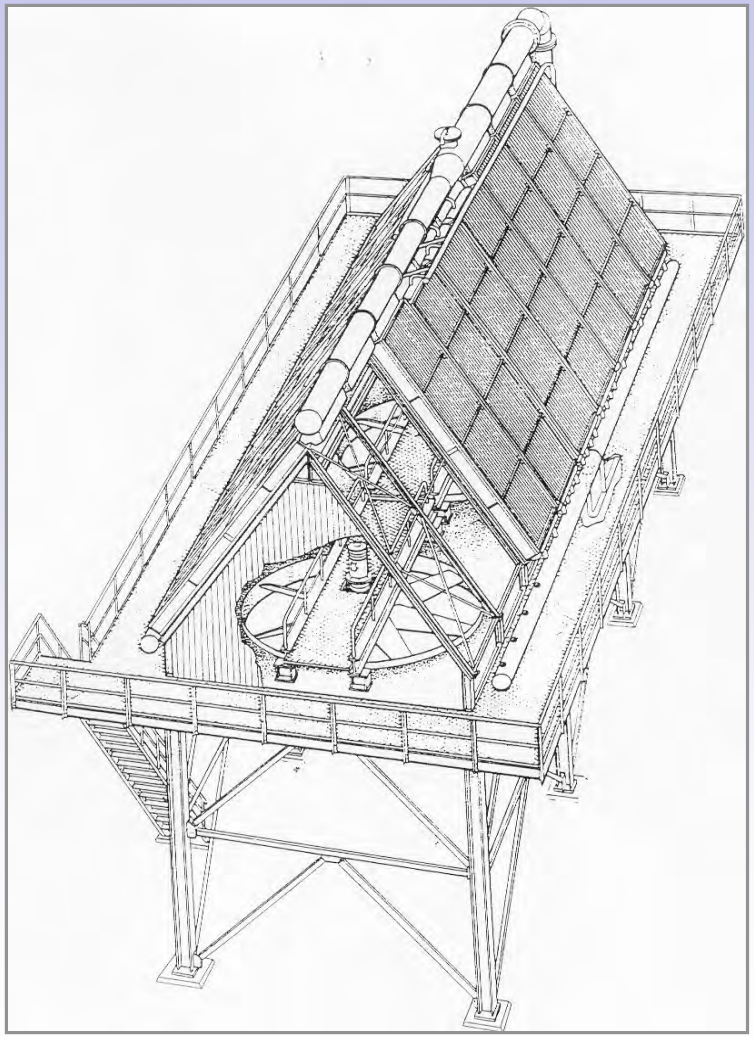
Air Cooled Condenser



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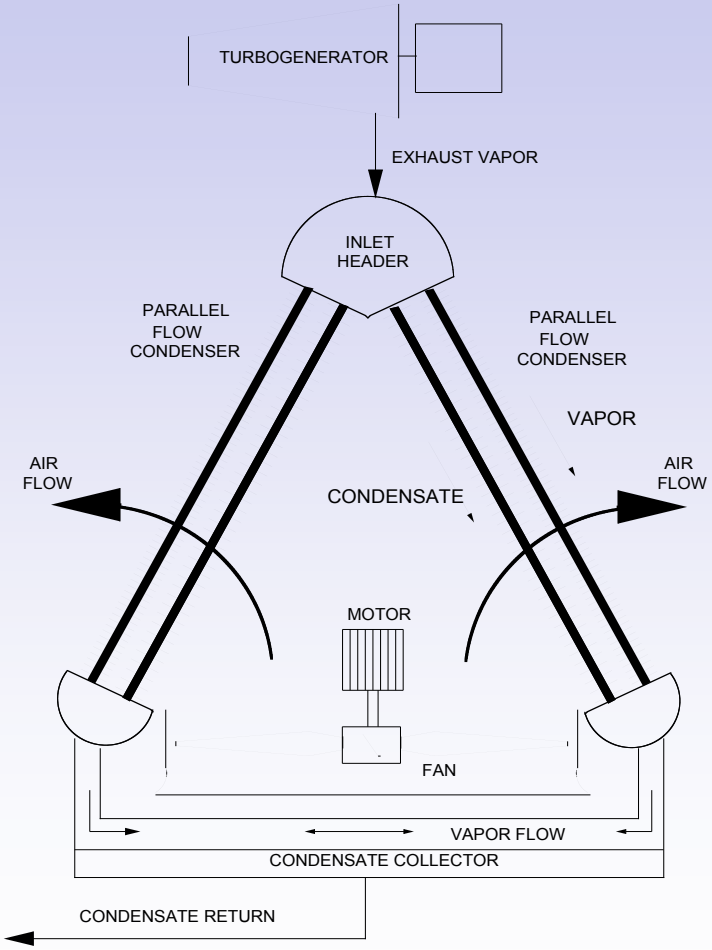
Parallel Flow Panels



AIR-COOLED CONDENSER

PARALLEL FLOW SECTIONS

FIGURE 2.0

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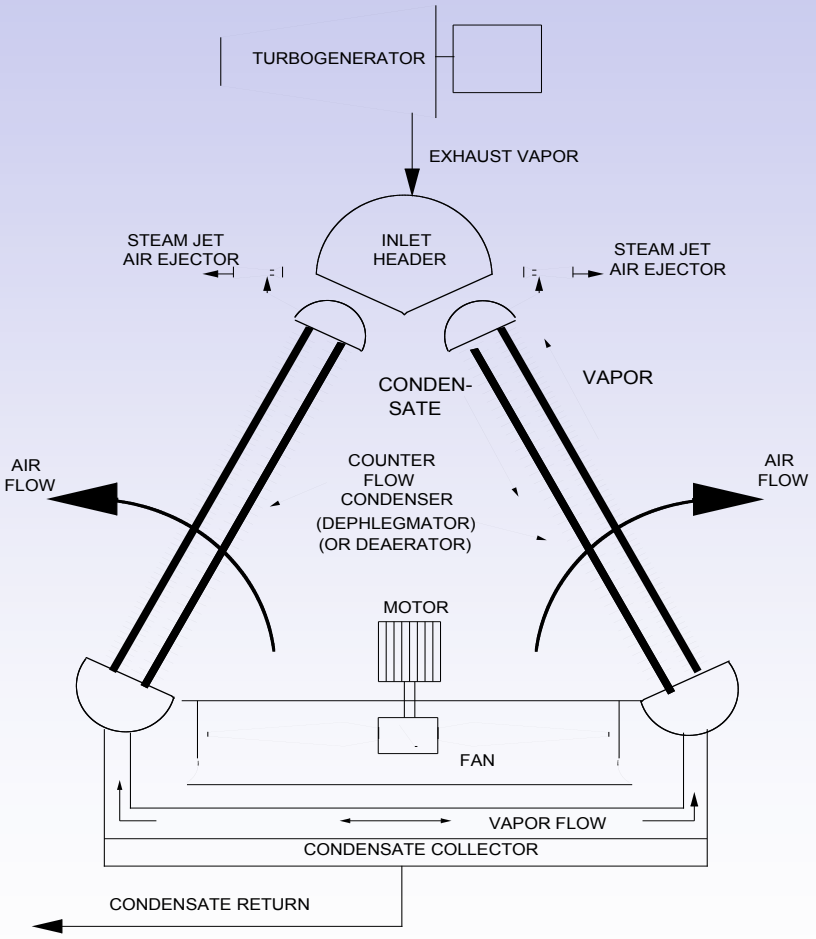
Deaerator Panels



AIR-COOLED CONDENSER
DEAERATOR SECTION
FIGURE 3.0

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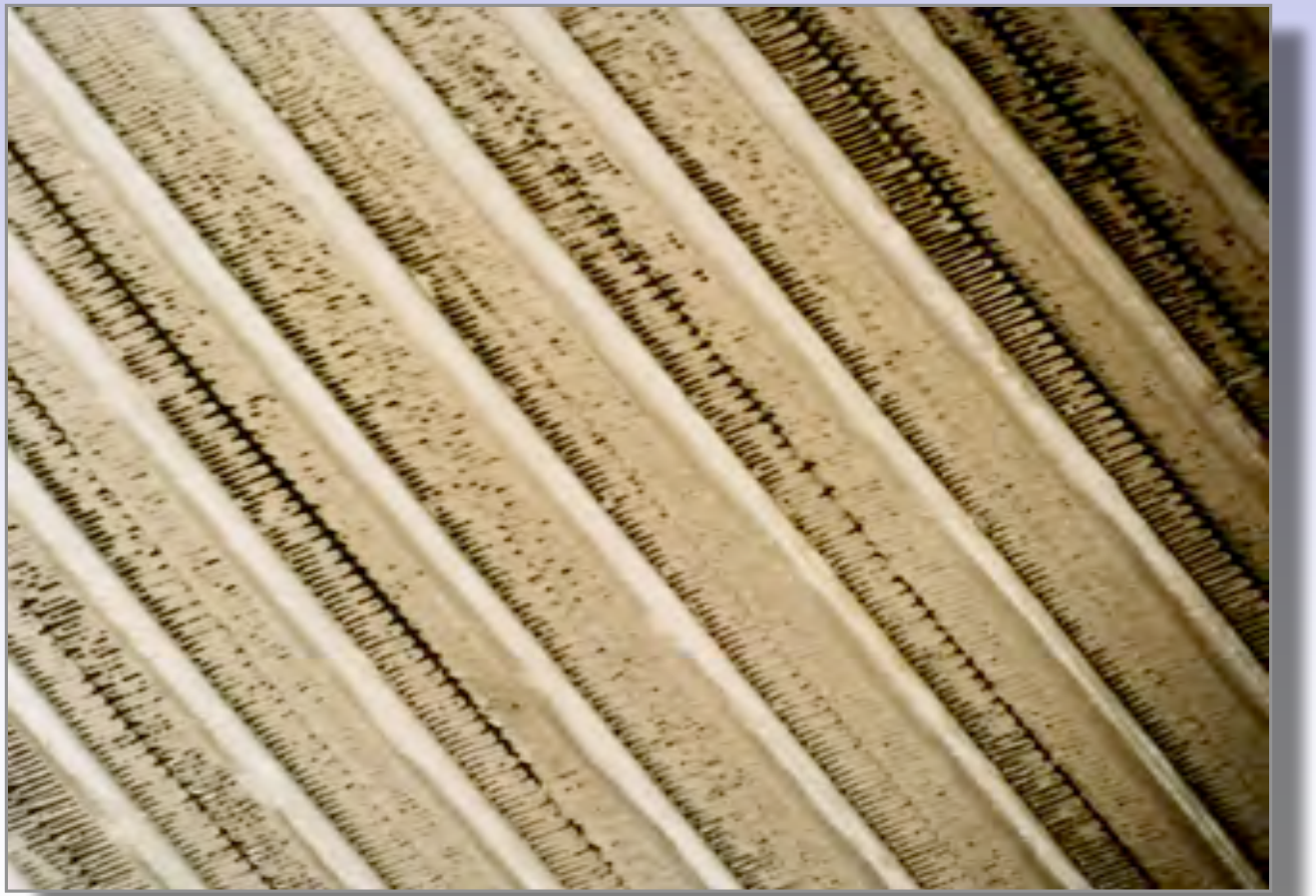
Fouling Tendencies

- Finned tubes tend to collect pollen, dust, insects, plastic bags, bird carcasses, etc.
- Reduced air flow rate reduces heat transfer which increases heat rate and/or reduces generation capacity
- Water, sometimes sprayed on tubes during high ambient temperature periods, can lead to the formation of scale on tube fins thus reducing the heat transfer rate

Fouled External Surface



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Impact of Fouling

- Poor heat transfer
- Higher operating costs
- Increased power supply of fandrive motors
- Deterioration of turbine back pressure
- Restricted MW output

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Operating Criteria

- Ambient Air Temperature
- Air temperature rise across tube banks
- Pressure drop across tube banks
- Pressure rise across fans
- Condenser back pressure
- Condenser Duty:

$$Q = W_{cond} \ (H_{vap} - H_{liq})$$

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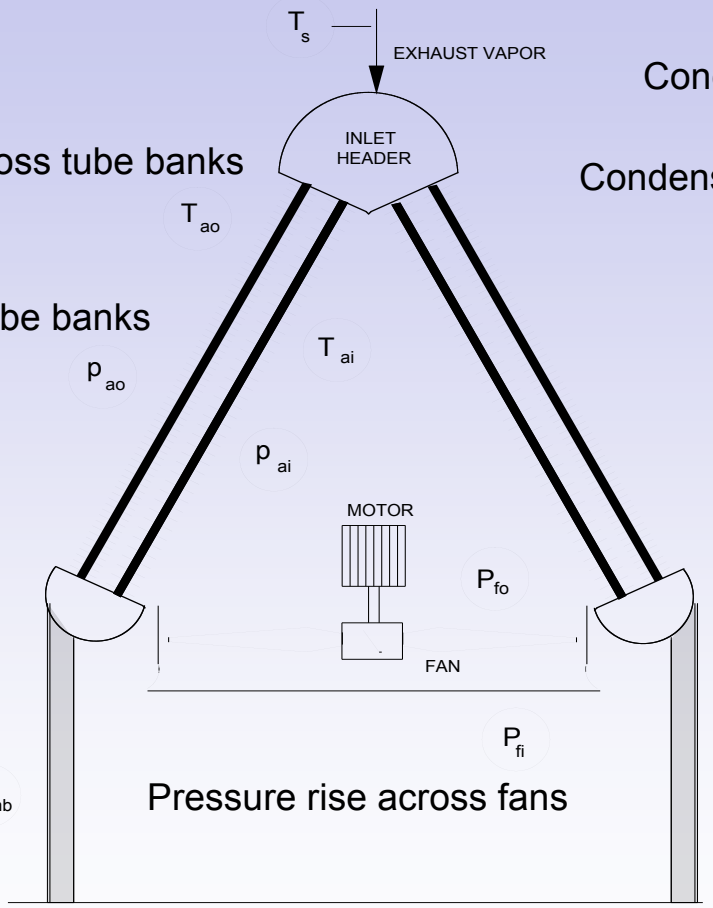
Instrumentation



Condenser back pressure

Air temperature rise across tube banks

Condenser Duty:

$Q = Wcond\ (Hvap - Hliq)$

Pressure drop across tube banks

Ambient Air Temperature

Pressure rise across fans

AIR-COOLED CONDENSER

INSTRUMENTTAION

FIGURE 4.0

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Operating Data Correlation

- ASME is moving forward with performance standards and an industry draft is expected by year end.
- Two common ways of presenting air cooled condenser performance data:
  - Expected condenser duty plotted against inlet dry bulb air temperature for various values of condenser back pressure
  - Expected condenser back pressure plotted against percent design air flow for various values of ambient air temperature

Cleaning Techniques

Three principal methods of cleaning an air cooled condenser:

- Fire hose
- High pressure handlance
- Automated cleaning machine

Fire Hose

- High volume of water but low washing effect
- Unit must be taken out of service and scaffolding erected
- Improvements are quite small, since only a portion of debris is removed, remainder being compacted between tube fins

High Pressure Handlance

- Low water consumption and a high water pressure
- Latter can damage galvanized surfaces and/or snap off fins
- Unit must be taken out of service and scaffolding erected
- Again, improvements are quite small since only portion of debris is removed, remainder being compacted between tube fins

Automated Cleaning Machine

- Nozzle beam optimally matched to tube bundle geometry with a constant jet angle
- 60 GPM at 1,000-2,000 psi water pressure avoids fin and tube surface damage
- Nozzle design, distance from surface and jet energy adjustable
- Carriage moves at a constant speed
- Water contains no additives
- Fouling removed effectively and uniformly
- No need to shut unit down or erect scaffolding

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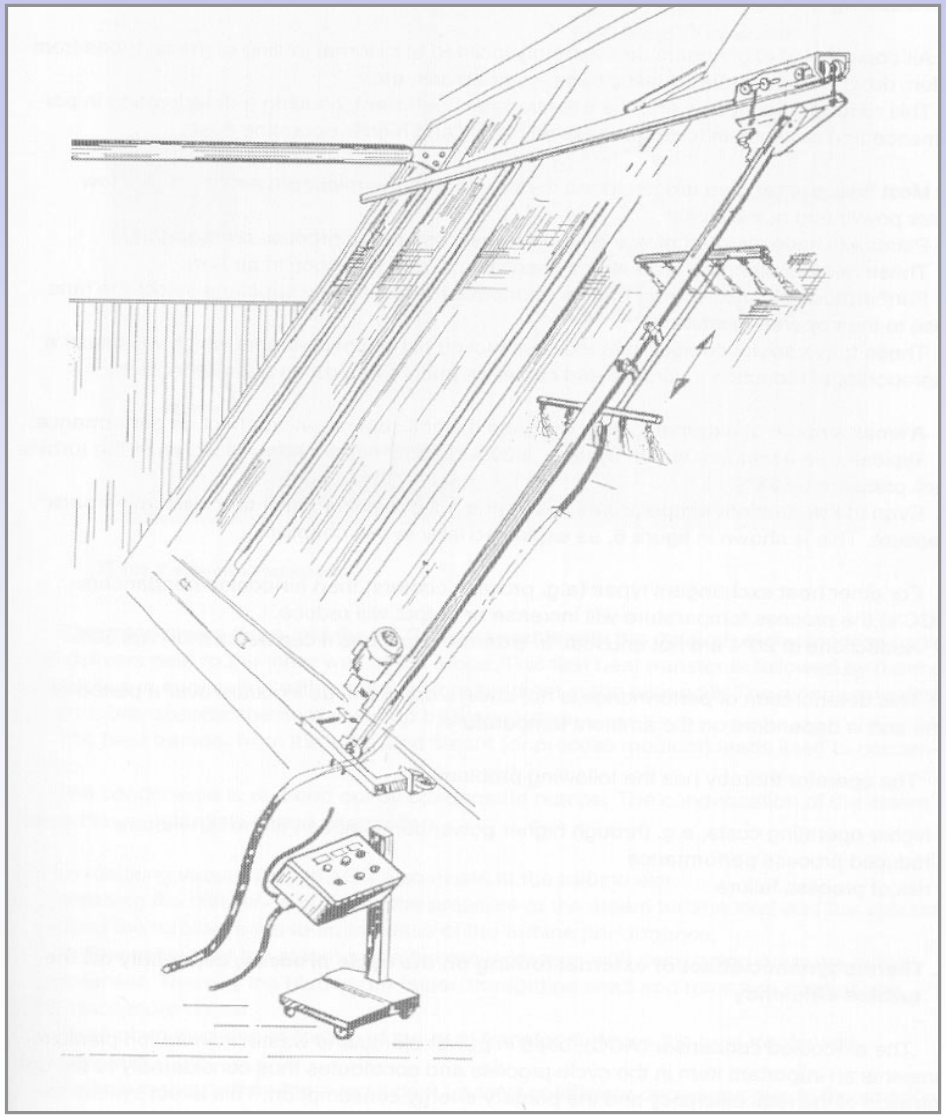
Permanently Installed System



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Nozzle Beam

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Nozzle Satisfies Fin Geometry

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Semi-Automated System

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Portable System

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Cleaning Results

Fouled

During Cleaning

Cleaned

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Performance Improvements

- Cleaning almost invariably allows fan speeds to be reduced, reducing auxiliary power consumption
- In some plants, cleaning can also result in increase in generation capacity (e.g. from 15 MW to 18 MW)
- Economic savings from cleaning can be estimated using simple calculations. In one UK plant it was estimated to be $18,476 /week

Economic Efficiency Calculation for a 400 MW power plant

8 mbar		**≈**	**1 MW**	**≈** **$45.00**
Before cleaning	turbine back pressure			130 mbar
After cleaning	turbine back pressure			100 mbar
Difference	**30 mbar**	**≈**	**3.8 MW**	

Increase in weekly revenue after cleaning:

3.8MW x 45.00 $ x 7 days x 24h x 75% running time =

$21,546.00 $/week

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Conclusions

- Air cooled condensers are a viable alternative to steam surface condensers.
- They allow a plant to be built on sites that are otherwise subject to impossible design constraints.
- Because of the fouling tendencies air cooled condensers require effective cleaning systems.
- Performance improvements may be achieved by maintaining the cleanliness of the external surfaces.